International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 458-465, 2020

RESEARCH PAPER OPEN ACCESS

Age and growth rate studies of *Cedrus deodara* (Roxb. ex D. Don) around Kashmir point Reserve Forest of Tehsil Murree

Sohaib Muhammad*, Muhammad Tayyab, Zaheer-ud-din Khan, Sarah Maryam Malik, Nimra Akram

Dendrochronology Lab., Department of Botany, Govt. College University, Lahore, Pakistan

Key words: Dendrochronology, Kashmir point, *Cedrus deodara,* Velmex, Regression

http://dx.doi.org/10.12692/ijb/15.3.458-465 Article published on September 30, 2019

Abstract

This research is focused on Age and growth rate studies of *Cedrus deodara* around Kashmir Point Reserve Forest. Fifty nine cores were extracted from this forest and in some trees two cores per tree were also taken, having large diameter. Velmex Measuring System was used in cross dating of each sample. Some samples were with cracks, scars, thin-skinned rings and wounds, which can be due to a variety of events like fire, earthquakes, land sliding, insect attack etc. The maximum age of tree observed was 321 years and minimum was 43 years. Slow development (narrow rings) and rapid development (wide rings) of samples were also recorded. Most of the species were more than 150 years of age. Average growth rate was determined. Highest average growth rate was 6.39mm per year. Regression analysis was studied between Age/Dbh. Regression analysis graph between Age and Dbh showed linear line. Moreover, regression drawn between Age and Dbh was (y=5.070x+20.23) and (R^2=0.868) in first stand, (y=8.393x-24.70) and (R^2=0.429) in second stand, (y=6.637x+12.55) and (R^2=0.519) in third stand. So the maximum value observed was in in first stand which showed better correlation as compared to rest of stands.

* **Corresponding Author:** Sohaib Muhammad ✉ dr.sohaibmuhammad@gcu.edu.pk

Introduction

Dendrochronology deals with counting of the annual rings of a tree. Through this technique history of the past events occurred in nature can be recorded. Tree rings proved to be an effective parameter for studying the influence of external factors on growth rate of trees (Fritts and Swetnam, 1989; Bhuju and Gaire, 2012). In this field not only the age and growth rates of tree species can be determined but it can also be helpful in constructing the tree ring chronologies with respect to past environmental changes. Such construction of chronologies of tree rings are helpful in managing the forests, silviculture treatments, determination of past climate, past wild fires, earthquakes and hydrological aspects (Copenheaver *et al.,* 2006; Khan *et al.,* 2013).

While various workers from different parts of the world carried out research work at variable capacities in this field. For example Khan *et al.* (2008) conducted a research work to determine the age and growth rate of *Picea smithiana* with respect to the changes occurred in the climate and chronologies were developed for future studies (Ahmed *et al.,* 2012). Along with this Bokhari *et al.* (2013) determined the effects of earthquake on some pine species of Azad Jammu and Kashmir. Apart from this work some researchers carried out dendrochronological research in order to explore the various aspects like Song and Zhou (2015) determined age of *Haloxylon ammodendron* and tree ring structure was explained. Fontana *et al.* (2016) carried out an assessment to find out the dendrochronological potential of *Licaria bahiana* Kurz from atlantic forests of Brazil and showed that this tree had highest climatic sensitivity and growth synchrony.

By considering the impact of dendrochronological potential and ecological significance of the research area, present research work was carried out in order to determine the age and growth rate of *Cedrus deodara* Roxb. ex D. Don. tree in Kashmir Point Reserve Forest of Tehsil Murree. In this forest these *C. deodara* trees were considered to be oldest one in accordance with the reports of forest department of Tehsil Murree. Moreover, significance of this area is also highlighted due to the eocgeological importance of the research site. This region is a part of two ecological zones i.e., Chir zone (Sub Tropical Forest) and Kail zone (Moist Temperate Forest). So, due to its ecological importance this site is included in Global 200 eco-regions of the world (WWF-Pak, 2013). Determination of *C. deodara* age will help to develop tree ring chronologies and to develop better strategies for conservation of national tree in the area.

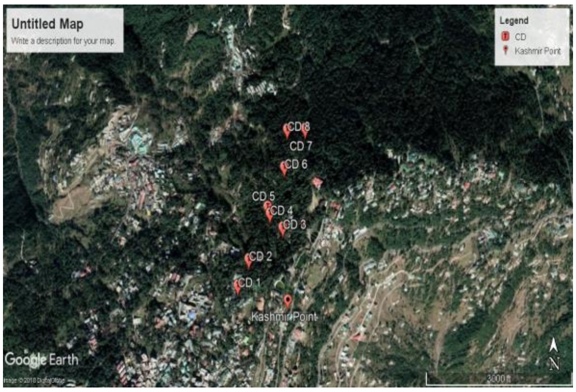
Materials and methods

Sampling

The core samples were obtained just from trees which were healthy, complete, un-branched, and rigid and upright having precise and consistent diameter. For an appropriate and correct age determination, cores were taken at height as 1.3m or 4.3 ft. above the base level with help of increment borer (Fritts, 1976). These were taken always in a straight position. The small hole created in trees during coring of trees was refilled by wax, so that tree will remain secure from any fungal or pathogen attack. Next step is packaging of cores. The borer was taken out from the tree and the core samples were preserved in special straws made up of plastic material, in order to protect it and to maintain the correct arrangement of core pieces. Both ends of the straw were covered properly with the help of a paper tape. GPS (Global Positioning System) was also used to find the locations, elevations and geographical coordinates of each site (Hart and Grissino-Mayer, 2008).

Preparation of samples for microscopic study

Then further process was proceeded in laboratory. Cores were placed on wooden frames or mount after drying them in air. The better selected core mounts were not thin and these were not too deep in the groove of frame. To fix these cores on frames, special glue was used to mount these properly. The paper tape was used to fix them until the glue dried. Then cores were followed in sanding method with a fine different sized sand paper like 80 grit, 100 grit, 120 grit or sometimes larger sized are also used as 320 grit and 400 grit. The most appropriate is used, depending upon the species used for this purpose. Then polishing was done so that these cores can be seen clearly as in form of rings i.e. every cell of cross section should be clear. Velmex Measuring System was used to measure the cross dated cores (Pilcher, 1990). To measure the tree rings, Voortech's Measure J2X was installed and connected to cables of this system. The core samples were placed on the stage of system one by one and then Stereo microscope was used to see the image clearly on laptop, at its upper side digital microscope is also attached so annual rings were counted and width between rings was measured automatically by this system (Volney and Mallet, 1992; Yamaguchi, 1991).



Map # 1. Tagging of *Cedrus deodara* at Kashmir Point Reserve Forest of Tehsil Murree (2017).

Map 2. Tagging of *Cedrus deodara* at Kashmir Point Reserve Forest of Tehsil Murree (2018).

Results and discussion

Results were compiled by dividing sampling into three parts Kashmir Point Reserve Forest (2017), Kashmir Point Reserve Forest (2018). The location, Dbh, age and rate of growth of different core samples of *C. deodara* trees of Kasmir Point Reserve Forest (2017) is given in Table 1.1. And the location, diameter at breast height, age and growth rate of different core samples of *C. deodara* trees of Kashmir point Reserve Forest (2018) is given in Table 1.2a & b.

The following results were obtained after measurement of cores under Velmex Measuring System:

Table 1.1. Age, Growth Rate and Dbh (inches) of *Cedrus deodara* of Kashmir Point Reserve Forest (2017).

Sr. No.	Core No.	Rings count	Growth (mm)	Average growth (mm)	Average Growth (inches)	Circumference (ft)	Dbh (inches)	Age (Years)	GPS (N)	GPS (E)
1	CD 1	49	208.5	3.15	0.12	13.1	49.2	289	33.91147	73.39962
2	CD 1'	39	136.8	3.48	0.13	13.1	49.2	249	33.91147	73.39962
3	CD 2	79	176.5	2.23	0.08	9.11	34.8	219	33.91252	73.40027
4	CD 2'	49	144.4	2.94	0.11	9.11	34.8	187	33.91252	73.40027
5	CD 3	47	187.4	3.98	0.15	5.8	21.6	152	33.91378	73.40226
6	CD 3'	52	146.7	2.82	0.11	5.8	21.6	123	33.91378	73.40226
7	CD 4	40	176.7	4.41	0.17	4.3	15.6	106	33.91433	73.4015
8	CD 4'	34	133	3.91	0.15	4.3	15.6	79	33.91433	73.4015
9	CD 5	39	166.7	4.27	0.16	4.3	15.6	97	33.91459	73.40136
10	CD 5'	32	174	5.43	0.21	4.3	15.6	104	33.91459	73.40136
11	CD 6	68	191	2.8	0.11	4.4	16.8	125	33.91619	73.40235
12	CD 6'	53	154	2.9	0.11	4.4	16.8	97	33.91619	73.40235
13	CD 7	68	178.6	2.62	0.1	5.8	21.6	146	33.91774	73.40359
14	CD 7'	68	189.2	2.78	0.1	5.8	21.6	146	33.91774	73.40359
15	CD 8	37	85.3	2.3	0.09	6.3	24	79	33.91773	73.40252
16	CD 8'	51	168.4	3.3	0.12	6.3	24	146	33.91773	73.40252

**CD* stands for *Cedrus deodara*; **Dbh stands for diameter at breast height; ***GPS stands for Global Positioning System.

Table 1.2a. Age, Growth Rate and Dbh of *Cedrus deodara* of Kashmir Point Reserve Forest (2018).

Sr. No.	Core No.	Rings count	Growth (mm)	Average growth (mm)	Average Growth (inches)	Circumference (ft)	Dbh (inches)	Age (Years)	GPS (N)	GPS (E)
1	CD 1	140	172.4	1.23	0.04	6.4	24	134	33.91244	73.39905
2	CD 2	74	138.3	1.86	0.07	3.1	10.8	55	33.91371	73.40057
3	CD 3	45	104.7	2.32	0.09	2.9	10.8	43	33.91903	73.40078
4	CD 4	53	195.7	3.69	0.14	4.9	18	133	33.92912	73.41128
5	CD 5	71	188.3	2.65	0.1	7.7	28.8	204	33.9141	73.40111
6	CD 5'	51	155.2	3.04	0.11	7.7	28.8	161	33.9141	73.40111
7	CD 6	64	159.1	2.48	0.09	5.2	19.2	110	33.91395	73.40113
8	CD 6'	55	351.7	6.39	0.25	5.2	19.2	264	33.91395	73.40113
9	CD 7	77	156.1	2.02	0.07	3.8	14.4	77	33.90212	73.40135
10	CD 7'	66	144.4	2.18	0.08	3.8	14.4	76	33.90212	73.40135
11	CD 8	64	359.6	5.61	0.22	6.2	22.8	321	33.9141	73.4012
12	CD 8'	52	180.9	3.48	0.13	6.2	22.8	154	33.9141	73.4012
13	CD 9	40	150.1	3.75	0.14	3.5	13.2	73	33.9125	73.40125
14	CD 10	113	145.5	1.28	0.05	5.2	19.2	108	33.91471	73.40173
15	CD 11	74	163	2.2	0.08	5.7	21.6	127	33.91791	73.40372
16	CD 12	68	215.7	3.17	0.12	5.7	21.6	176	33.91791	73.40372
17	CD 13	156	159.7	1.02	0.04	6.8	25.2	157	33.91779	73.40344
18	CD 14	59	180.5	3.06	0.12	6.8	25.2	178	33.91782	73.40355
19	CD 15	81	189.7	2.34	0.09	6	22.8	166	33.91784	73.40347
20	CD 16	91	212	2.33	0.09	5.7	21.6	176	33.91789	73.4035
21	CD 17	59	204.5	3.46	0.13	6	22.8	174	33.9179	73.40348

**CD* stands for *Cedrus deodara*; **Dbh stands for diameter at breast height; ***GPS stands for Global Positioning System

Table 1.2b. Age, Growth Rate and Dbh of *Cedrus deodara* of Kashmir Point Reserve Forest (2018).

Sr. No.	Core No.	Rings count	Growth (mm)	Average growth (mm)	Average Growth (inches)	Circumference (ft)	Dbh (inches)	Age (Years)	GPS (N)	GPS (E)
22	CD 18	74	218.9	2.95	0.11	4.9	18	146	33.91783	73.40341
23	CD 19	76	204.2	2.68	0.1	6.11	22.8	173	33.91779	73.40338
24	CD 20	47	100	2.12	0.08	4.9	18	67	33.91785	73.40344
25	CD 21	85	277.1	3.26	0.12	6.8	25.2	257	33.91797	73.4034
26	CD 22	71	201	2.83	0.11	6.8	19.2	149	33.91797	73.4034
27	CD 23	69	217	3.14	0.12	6.1	22.8	188	33.91797	73.40341
28	CD 24	65	197.3	3.03	0.11	6.1	22.8	163	33.91797	73.40341
29	CD 25	72	213.5	2.96	0.11	6.9	25.2	199	33.91797	73.4034
30	CD 26	65	116.5	1.79	0.07	5.5	20.4	92	33.91801	73.40338
31	CD 27	68	149.3	2.19	0.08	9.1	33.6	182	33.91783	73.40342
32	CD 28	85	219.7	2.58	0.1	5.11	19.2	163	33.91791	73.40465
33	CD 29	94	220.3	2.34	0.09	5.11	19.2	162	33.91791	73.40465
34	CD 30	82	168.3	2.05	0.08	4.1	15.6	102	33.91806	73.4052
35	CD 31	87	183.6	2.11	0.08	3.5	13.2	91	33.91812	73.40525
36	CD 32	79	202.6	2.56	0.1	7	26.4	208	33.91801	73.40564
37	CD 33	95	175.6	1.84	0.07	6	22.8	151	33.91991	73.40785
38	CD 34	107	201.5	1.88	0.07	6	22.8	170	33.91991	73.40785
39	CD 35	116	189.6	1.63	0.06	8	30	208	33.91955	73.40776
40	CD 35'	86	186.8	2.17	0.08	8	30	206	33.91955	73.40776
41	CD 36	75	200.5	2.67	0.1	6	22.8	171	33.91973	73.40797
42	CD 37	65	202.2	3.11	0.12	5.1	19.2	149	33.91982	73.41669
43	CD 38	58	167.1	2.88	0.11	6.2	22.8	145	33.91976	73.41666

**CD* stands for *Cedrus deodara*; **Dbh stands for diameter at breast height; ***GPS stands for Global Positioning System.

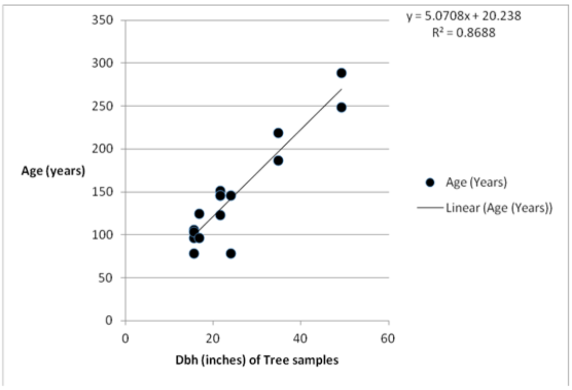


Fig. 1.1. Correlation between Dbh (inches) and age (years) of trees of *Cedrus deodara* of Kashmir Point Reserve Forest.

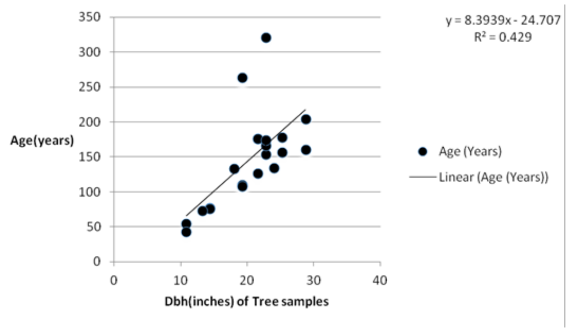


Fig. 1.2a. Correlation between Dbh (inches) and age (years) of trees of *Cedrus deodara* of Kashmir point Reserve Forest.

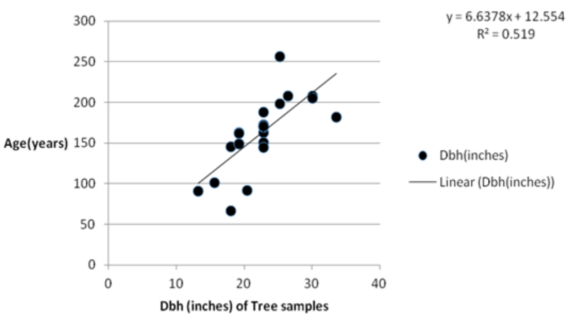


Fig. 1.2b. Correlation between Dbh (inches) and age (years) of trees of *Cedrus deodara* of Kashmir Point Reserve Forest.

Age, Growth rate and Dbh of C. deodara of Kashmir Point Reserve Forest (2017)

The location, Dbh, age and rate of growth of different *C. deodara* trees present at Kashmir point reserve forest (2017) is given in Table 4.1. Sixteen cores from different *C. deodara* trees were taken and two cores per tree were taken and each core was given a particular core name i.e. *CD1 to CD 8'*. The trees of different Dbh have varied age and growth rate. Overall the *C. deodara* growing had the age among 100 to 140 years. The rate of growth changes between 0.08 to 0.21 inches/year. *CD1* was oldest tree of 289 years (diameter of 49.2 inches) and rate of growth was 0.12 inches/year. *CD 4 and CD 8* were youngest trees of 79 years (diameter of 15.6 and 24 inches) respectively and rate of growth was 0.15 and 0.09 inches/year respectively.

The correlation between the age and Dbh of *C. deodara* was observed positive, has been shown in fig. 4.1. Dbh was examined as with direct relation to the age in almost every tree; as if diameter of the tree is greater then age of the corresponding tree will also be greater.

Age, Growth rate and Dbh of C. deodara of Kashmir Point Reserve Forest (2018)

The location, Dbh, age and rate of growth of different *C. deodara* trees present at Kashmir point reserve forest (2018) is given in Table 4.2 a & b. Forty three cores from different *C. deodara* trees were taken and two cores per tree were taken and each core was given a particular core name i.e. *CD1 to CD* 43. The trees of different Dbh have varied age and ate of growth. Overall the *C. deodara* growing had the age among 100 to 180 years. The rate of growth changes between 0.04 to 0.25 inches/year. *CD8* was oldest tree of 321 years (diameter of 22.8 inches) and rate of growth was 0.22 inches/year. *CD 3* was youngest trees of 43 years (diameter of 10.8) and rate of growth was 0.09 inches/year.

The correlation between the age and Dbh of *C. deodara* was observed positive, has been shown in fig. 4.1. Dbh was examined as with direct relation to the age in almost every tree; as if diameter of the tree is greater then age of the corresponding tree will also be greater.

Discussion

There was a range seen among distinctive sites of the identical species with a few growing at over twice the rate than others (as *C. deodara* at Kashmir point). So, it follows that the slower developing sites are better prospects for climatic studies. Therefore, the better prospects are with better growth increasing rate. Moreover, there are variations in ecological tolerances by using species and best with protecting a species and relationship be showed (Ahmed *et al.*, 2011). In Pakistan besides *Pinus wallichiana* no other gymnosperm like *Cedrus deodara, Taxus wallichiana, Picea smithiana, Pinus roxburghii, Abies pindrow* and lots of others display no such a tremendous and highly direct relation between age and dbh. Ahmed and Sarangezai (1991) reported that diameter is not effective indicator of age in most trees, as despite the fact that in some trees species, age will increase with the increase in dbh nevertheless the changes remain very high in these species. Because many are in different environmental conditions and different altitude and consequently a species shows a high fluctuation in correlation among diameter and age. Accordingly, due to impact of environmental conditions largest one is not always the oldest in some perspectives, the population is same for the oldest tree (Ahmed and Sarangezai, 1991; Ahmed *et al.*, 2009; Bhuju and Gaire, 2012).

Many anthropogenic activities such as fire, logging, trees cutting and overgrazing also play an important role in affecting rate of growth of *C. deodara* and other gymnosperms. Important factor is competition that influences the ability to survive the different species, so resulting in reduction of rate of growth, depending on the resources availability mainly nutrients, water and sunlight. Moreover, diseases are also source of changes in rate of growth.

From Table 1.1and 1.2 (a & b) it is clear that the formation of double ring or false is ring is short in *C. deodara* and the false rings also form in young trees. (Borgaonkar *et al.,* 1999) have also given these same consequencies for Himalayan conifers genus (i.e. *Picea, Pinus, Cedrus*, *Abies*. etc.) by examining chronology of tree rings. They get more than three hundred tree core samples from eleven sites covering an area of the Western Himalaya. They noticed proper growth and low formation of missing or double rings as the typical characteristics of Himalayan conifers. While according to (Brown *et al.* 2011) fire scars were also reported at false ring boundaries and show burning during the warm and dry period in May or early June before the onset of monsoon in *P. wallichiana*.

False rings formation is not uniform all over the tree because the signal to form late wood originates from the effective meristem at the lateral position. Therefore, branches and stem parts that are near actively growing branches are like false ring than lower branches part of the stem. Trees younger in age and trees with better growth are also seen to form false rings (Vogel *et al.,* 2001). That's why in younger trees the false rings are more likely to be present. The *P. wallichiana* tree with diameter of 20.5 inches from the Zhob district have an age of 112 years, while the age was determined from a tree of similar species is same having a diameter of 65 cm from Ayubia. Similarly, a sample from Murree had 351 rings with Dbh of only 11.3 cm were noted (*A. pindrow*), while a 200cm was noted in *C. deodara* from Kalam and it had growth of 346 years. (Ahmed *et al.*, 2011). Here tree of *C. deodara* with a 22.8 dbh from Tehsil Murree reserve forest attained an age of 321 years. (Table 1.2a). While in same species, in Ayubia National Forest the maximum age recorded is 120 years with Dbh of 15.6). The relationship between age and dbh for *P. gerardiana, J. excelsa*, *A. pindrow* and *P. wallichiana* (Ayubia) was highly significant. Recently, they determined age and growth rate data from thirty nine locations, using various Gymnosperm trees. If the diameter is a good sign of age, then records of the appropriate stand are convinced. Therefore, the present study is concerned like with *C. deodara*, this cannot be feasible due to a large change in environmental condition and other disturbances. In the present time, these changes show a tremendously better correlation. (Table 1.1 and 1.2a, 1.2b).

Recommendations

Dendrochronology may prove beneficial in the better understanding about plant structure in relation to environmental factors. These relations can be better understood if we have appropriate parameters to assess the plant structure. By using the processed based model infrastructure and the appropriate statistics, the plant physiology and anatomy can be better understood than the previous study. There is a need to understand about the plants, population and communities over time scales. This area of study (Kashmir point) has much better growth of *C. deodara* (Max. 321 years) and (Min. 43 years). *C. deodara* shows growth in too much stress as compared to that of other conifers like *P. wallichiana* so there is need to reserve this forest properly as any environmental or anthropogenic activity may disturb the growth of all conifers.

References

Ahmed M, Khan N, Wahab M, Zafar U, Palmer J. 2012. Climate/Growth correlations of tree species in the Indus Basin of the Karakoram range of North Pakistan. International Association of Wood Anatomists Journal **33,** 51-61.

Ahmed M, Palmer J, Khan N, Wahab M, Fenrick P, Esper CE. 2011. The dendroclimatic potential of conifers from Northern Pakistan. Dendrochronologia **29,** 77-88. https://doi.org/10.1016/j.dendro.2010.08.007

Ahmed M, Sarangezai AM. 1991. Dendrochronological approach to estimate age and growth rate of various species from Himalayan region of Pakistan. Pakistan Journal of Botany **23,** 78-89.

Ahmed M, Wahab M, Khan N, Siddiqui MF, Khan MU, Husain ST. 2009. Age and growth rates of some gymnosperms of Pakistan: A dendrochronological approach. Pakistan Journal of Botany **41,** 849-860.

Altman J, Dolezal J, Zek LC. 2016. Age estimation of large trees: New method based on partial increment core tested on an example of veteran Oaks. Forest Ecology and Management **380,** 82-89. https://doi.org/10.1016/j.foreco.2016.08.033

Bhuju DR, Gaire NP. 2012. Plantation history and growth of old pine stands in Kathmandu valley: A dendrochronologial approach. FUUSAT Journal of Biology **2,** 13-17.

Bokhari TZ, Ahmed M, Khan Z, Siddiqui MF, Zafar MU, Malik SA. 2013. Dendrochronological potential of pine tree species of Azad Jammu and Kashmir-Pakistan: A preliminary study. Pakistan Journal of Botany **45,** 1865-1871.

Borgaonkar HP, Pant GB, Kumar KR. 1999. Tree ring chronologies from western Himalaya and their dendroclimatic potential. International Association of Wood Anatomists Journal **20,** 295-309.

Brown PM, Bhattacharyya A, Shah SK. 2011. Potential for developing fire histories in Chir Pine (*Pinus roxburghii*) forests in the Himalayan foothills. Tree Ring Research **67,** 57-62.

Copenheaver CA, Pokorski EA, Currie JE, Abrams MD. 2006. Causation of false ring formation in *Pinus banksiana*: A comparison of age, canopy class, climate and growth rate. Forest Ecology Management **236,** 348-355. https://doi.org/10.1016/j.foreco.2006.09.020

Fontana C, Santini-Junior L, Olmedo GM, Botosso PC, Tomazello-Filho M, Oliveira JM. 2019. Assessment of the dendrochronological potential of *Licaria bahiana* Kurz, an endemic laurel of lowland Atlantic forests in Brazil. Acta Botanica Brasilica **33,** 454-464.

Fritts HC, Swetnam TW. 1989. Dendrochronology: A tool for evaluating variations in past and present forest environments. Advances in Ecological Research **19,** 111-188.

Fritts HC. 1976. Tree Ring and Climate. Academic Press, London p. 545.

Haines HA, Gadd PS, Palmer J, Olley JM, Hua Q, Heijnis H. 2018. A new method for dating tree rings in trees with faint indeterminate ring boundries using Itrax core scanner. Paleogeography, Paleoclimatology & Paleoecology **497,** 234-243. http://doi.org/10.1016/j.palaeo.2018.02.025

Hart JL, Grissino-Mayer HD. 2008. Vegetation patterns and dendroecology of a mixed hard wood forest on the Cumberland Plateau: Implications for stand development. Forest Ecology and Management **225,** 1960-1975. doi:10.1016/j.foreco.2007.12.018

Khan N, Ahmed M, Shaukat SS. 2013.Climatic signal in tree ring chronologies of *Cedrus deodara* from Chitral Hindukush Range of Pakistan. Geochronometria **40,** 195-207.

Khan N, Ahmed M, Wahab M. 2008. Dendrochronological potential of *Picea smithiana* (Wall) Boiss. From Afghanistan. Pakistan Journal of Botany **40,** 1063-1070.

Pilcher JR. 1990. Sample preparation, cross-dating and measurement. In: Cook ER and LA Kairiukstis (eds.). Methods in dendrochronology. International Institute for Applied Systemanalysis, Dordecht, Netherland p. 40-51.

Song Y, Zhou C. 2015. Multiple bands characteristics of tree ring and age of *Haloxylon ammodendron* in Gurbantunggut desert. Pakistan Journal of Botany **47,** 615-622.

Vogel JC, Fuls A, Visser E. 2001. Radiocarbon adjustments to the dendrochronology of a yellow wood tree. South African Journal of Science **97,** 164-166.

Volney WJA, Mallet KI. 1992. Light rings and the age of jack pine trees. Canadian Journal of Forest Research **22,** 2011-2013. https://doi.org/10.1139

WWF-Pak (World Wide Fund for Nature-Pakistan). 2013. Land cover change analysis of Murree forest division . GIS laboratory, WWf-Pak., Lahore p. 7.

Yamguchi DK. 1991. A simple method for cross-dating increment cores from living trees. Canadian Journal of Forest Research **21,** 414-416. https://doi.org/10.1139/x91-053